

New glass furnace with energy efficiency features and improved insulation

Lax & Shaw



- Energy savings worth £312,800/year
- Payback period 7 months (16 months, industry typical)
- Potential replication by many large glass operators



ENERGY EFFICIENCY

BEST PRACTICE
PROGRAMME

HOST ORGANISATION



Over the last 15 years, the plant has been progressively modernised. The main opportunities to modernise have arisen as the furnaces have been fully rebuilt at the end of their campaigns. Furnace life between rebuilds has averaged around six years.

It is important that we carefully evaluate and implement process improvements in all areas of the plant at these times to plan continued reductions in operating costs.

The furnaces in particular are very difficult to modify once a campaign has begun. It is equally important that we balance potential cost savings against our aspirations for improved quality and flexibility.

In this case, we targeted areas of the furnace where we were confident that we could make impressive melting cost savings, and improve operating consistency. This in turn further guarantees glass quality. We anticipate that the improvements we have added will also add to the campaign life of the furnace, which should now extend to eight years.

The results from the combination of improvements we have added to No. 1 furnace have exceeded our expectation and after almost two years' continuous operation the furnace continues to perform better than our initial aspiration for melting cost and to produce a consistently high glass quality.

A handwritten signature in dark ink, appearing to read 'A Spencer', with a stylized flourish at the end.

Andrew Spencer
Chairman & Managing Director, Lax & Shaw Ltd

LAX & SHAW LTD

Lax & Shaw Ltd is based in Leeds, where it has been making glass containers since 1891. The plant currently manufactures white flint glass bottles predominantly for the UK liquor market. It specialises in high quality bottles for premium spirits brands, with a high proportion of products being supplied to the Scotch whisky industry.

The company employs 400 people, and produces around 220 million bottles annually from two furnaces which each melt over 50,000 tonnes of glass.

BACKGROUND AND OBJECTIVES

Glass manufacture is a high temperature, energy intensive process. Central to the operation is the furnace, which consumes between 70% and 80% of the total process energy. Glass melting furnaces, typically lasting up to ten years, are basically refractory box-like structures that operate continuously. These furnaces mostly burn fossil fuels for their energy requirements, usually natural gas or heavy fuel oil. A typical 200 tonne/day furnace has an annual melting and energy requirement of approximately 360 million MJ (100 million kWh).

The majority of large glass tank furnaces incorporate regenerative heat recovery systems. Improving the efficiency of these systems can lead to significant reductions in energy consumption.

Structural heat losses from such furnaces typically account for some 40% of the total heat input. The furnace crown, which experiences the highest working temperature within the furnace and which presents a large exposed surface area, is a major contributor to these losses.

The ingress of ambient air into the furnace cools the process, reducing thermal efficiency. Sealing either the furnace structure or the burner system to prevent this ingress contributes to better energy utilisation.

This Case Study demonstrates the cost and energy savings that can be achieved by incorporating a range of improvements into furnace design.

The furnace selected for the project was Lax & Shaw's No 1 furnace in Leeds. This was rebuilt in 1996, replacing the old No 1 furnace that was similar in basic design but which incorporated both electric boost and supplementary oxygen firing. The new No 1 tank is an end-fired regenerative furnace designed to produce up to 240 tonnes of flint container glass per day. It is normally fired on natural gas, but has a standby oil firing system allowing advantage to be taken of the cheaper interruptable tariff.

The new furnace incorporates several features that greatly improve its thermal efficiency, including:

- larger and more efficient regenerators;
- an enclosed doghouse;
- increased crown insulation;
- upgraded furnace, flue and regenerator insulation;
- sealed (lonox) burners;
- a deeper glass bath.

These features result in the new furnace using less energy than its predecessor to produce more glass. Furthermore, the new furnace uses neither electric nor oxygen boost, greatly reducing running costs.



The new furnace

The project was monitored independently by British Glass. Tel: 0114 268 6201.

The equipment was supplied by TECOGLAS Ltd. Tel: 0114 275 9020.

There may be other suppliers of similar services and energy efficiency equipment in the market.

Please consult your supply directories or contact ETSU who may be able to provide you with more details.

ENERGY SAVINGS

Weekly records of the tonnage of glass produced, and the various forms of energy consumed in the process, were recorded for both the 'old' and 'new' furnaces over a 12-month period. This gave sufficient data to produce reliable average values and avoided any climatic influences.

Fig 1 Energy consumption vs glass melted (old and new furnaces)

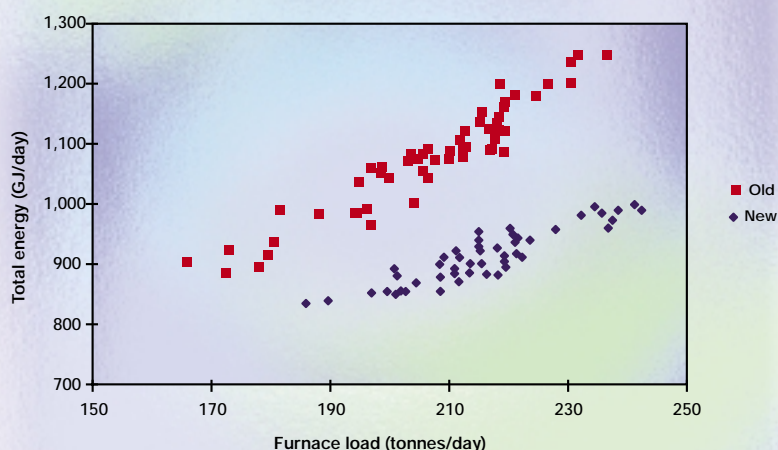
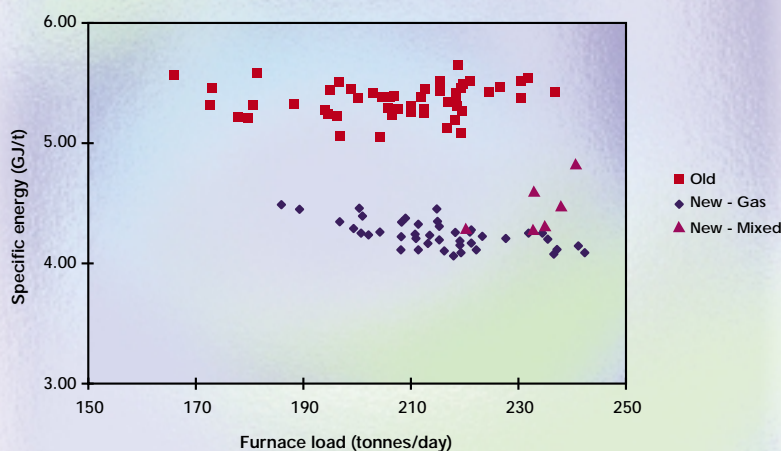


Fig 2 SEC vs glass melted (old and new furnaces)



CORRECTIONS FOR ELECTRICAL BOOSTING, OXYGEN ENRICHMENT, FURNACE SIZE AND AGE

The old furnace used both electrical boosting and oxygen enrichment. The new furnace uses neither. This complicates the process of comparison, as do differences in furnace size and age. For energy comparison within this study:

- (1) Electrical (Joule effect) heating was weighted by a factor of three to enable a fair comparison with delivered fossil fuels. This factor is close to the primary-to-delivered energy ratio for converting fossil fuels into electricity at power stations.
- (2) The energy input of the oxygen was calculated from the electrical energy needed to cryogenically separate the gas. A value of 0.41 kWh/Nm³ was used, again weighted by a factor of three, to allow for the ratio of primary to delivered energy. The energy value for the oxygen was added to that of the furnace to give a total delivered energy value.
- (3) Data from an industry-wide energy consumption guide¹ were used to derive a correction factor for size difference (see below), as the new furnace operates at a slightly higher load than its predecessor (212 cf 207 t/d).
- (4) The data from the old furnace represent a five-year old furnace. As furnaces get older their thermal efficiencies fall. The necessary compensating factors (see below) were derived from information obtained by British Glass² during extensive surveys into the effects of furnace ageing.

UNCORRECTED ENERGY SAVINGS

Comparable data from the two furnaces are shown in Figs 1 and 2. Fig 1 plots average energy consumption per day against glass 'pull'. Fig 2 plots the specific energy consumption (SEC) (defined here as energy per tonne of glass melted) against glass 'pull'. Figs 1 and 2 clearly demonstrate the improved thermal efficiency of the new furnace.

¹ Energy Efficiency Best Practice Programme: Energy Consumption Guide 27 – *The glass container industry*

² British Glass Technical Note No 318: *International survey of furnace performance of glass container furnaces, part 5 - lengths of campaigns and age.*

ENERGY SAVINGS

The data for the new furnace include several weeks when the company was obliged to fire on oil, due to the interruptable gas tariff in operation. Switching did not affect the operating performance of the furnace. Virtually no oil was used during the comparable period of old furnace operation. There was a significant difference between the SEC requirement when the tank consumed oil compared with gas so, for the purposes of a fair comparison, the data for the periods of oil firing have been disregarded in the final comparisons.

The old furnace used an average of 1,107 GJ to melt approximately 207 tonnes of glass per day. The corresponding values for the new furnace are 902 GJ to melt 212 tonnes of glass.

| | | | |
|-------|---------------------|---|-----------|
| Thus: | Old SEC | = | 5.35 GJ/t |
| | New SEC | = | 4.25 GJ/t |
| | Uncorrected Savings | = | 20.6 % |

CORRECTION FOR FURNACE AGE AND LOAD

(a) Age

An international survey carried out by British Glass², into the effects of ageing on glass furnace fuel efficiency found that, on average, end-fired furnaces decrease in efficiency by 2.5% per year. Recent developments in refractory materials have increased the typical campaign life of a glass melting furnace from seven to approximately ten years. An annual depreciation in efficiency of 1.75% is therefore a more realistic correction factor. Thus the 5-year correction required by the relative ages of the two furnaces is 9.1%.

(b) Load

The same survey², found a relationship between furnace load and their SEC where larger furnaces are more efficient by virtue of their size. The relationship took the form:

$$\text{SEC (GJ/t)} = e^{b \cdot [\text{load}]^a} \quad \text{where } a = -0.16841 \text{ and } b = 4.8814$$

The old and new furnaces operated at average loads of 207 and 212 tonnes per day. A correction factor of 0.6% is therefore required to bring the two cases to a common base.

CORRECTED ENERGY SAVINGS

The combined correction factor that must be applied to the old furnace case to correct for both age and furnace load is:

$$= \frac{(100 - 9.1)}{100} \times \frac{(100 - 0.6)}{100} = 0.904$$

| | | |
|-------------------------------|--|----------------------|
| Old furnace uncorrected SEC | = | 5.35 GJ/t |
| Old furnace corrected SEC | = <i>old furnace uncorrected</i> x 0.904 | = 4.84 GJ/t |
| New furnace SEC | = | 4.25 GJ/t |
| Energy savings per tonne | = <i>old (corrected)</i> - <i>new furnace</i> | = 0.59 GJ/t (12.2 %) |
| Total glass melted (per year) | = | 77431 t |
| Total annual consumption | = <i>tonnage</i> x <i>new furnace SEC</i> | = 329,100 GJ |
| Total annual savings | = <i>tonnage</i> x <i>energy savings per tonne</i> | = 45,700 GJ |

COST SAVINGS

Details of current energy prices, including standing charges, are given in Table 1 below.

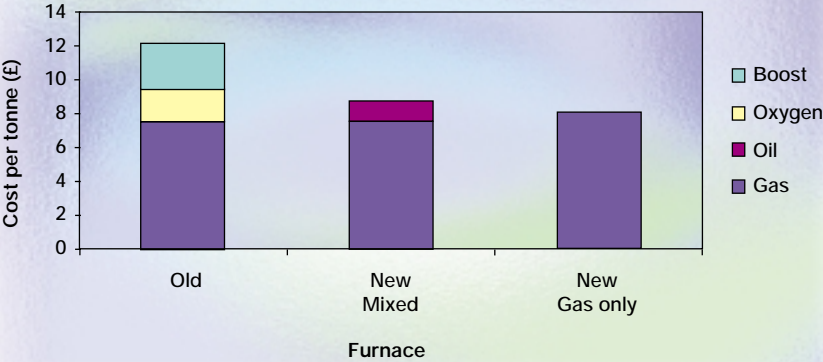
| Table 1 Energy costs (October 1997 – including standing charges) | | |
|--|-----------|--------|
| Fuel type | Price (£) | |
| Natural gas (inter) | 1.90 | per GJ |
| Heavy fuel oil | 3.84 | per GJ |
| Electricity | 10.17 | per GJ |
| Oxygen | 0.067 | per m³ |

MELTING COSTS PER TONNE OF GLASS MELTED

The relative cost to melt a tonne of glass for each case was derived from the mix of fuels used. Additional data for the new furnace shows the cost of the gas-only periods and this has been used in subsequent calculations. As with the energy data, the factor of 0.904, calculated above, has been used to adjust the cost figures to compensate for the difference in age and size between the two furnaces. These costs are presented in Table 2 below and also in Fig 3. Additional cost data for the new furnace during gas-only firing are also included. Here, ‘mixed-fired’ is the average over the entire year, which includes all oil and gas data. The ‘gas-fired’ is data for the new furnace minus the weeks when Lax & Shaw were obliged to use oil.

| Table 2 Specific melting costs | | | | |
|--------------------------------|--------------------------------|-------------------------|-------------------------|-----------------------|
| Fuel type | Cost per tonne of glass melted | | | |
| | Old furnace (uncorrected) | Old furnace (corrected) | New furnace mixed-fired | New furnace gas-fired |
| Natural gas (inter) | 8.20 | 7.41 | 7.60 | 8.06 |
| Heavy fuel oil | 0.03 | 0.03 | 1.15 | – |
| Electricity | 2.98 | 2.70 | – | – |
| Oxygen | 2.17 | 1.96 | – | – |
| Total | 13.38 | 12.10 | 8.75 | 8.06 |

Fig 3 Relative energy costs



The new furnace is seen to be melting glass at a cost of £8.06 per tonne. The corresponding value for the old furnace, after correction for size and age, is £12.10. The annual cost savings are calculated below:

| | | |
|---------------------------|---|------------------|
| Melting costs old furnace | = | £12.10 per tonne |
| Melting costs new furnace | = | £ 8.06 per tonne |
| Cost savings per tonne | = | £4.04 per tonne |
| Glass melted per annum | = | 77,431 tonne |
| Annual cost savings | = | £312,800 |

APPORTIONING INDIVIDUAL ENERGY SAVINGS

The total energy savings of 45,700 GJ per annum arise from the furnace design improvements specified. An assessment of the individual contribution of each measure is shown in Fig 4.

Investment Costs

Total investment costs were £2.8M (1997 prices). However, the rebuild was a scheduled event, and the marginal extra investment for specifying and

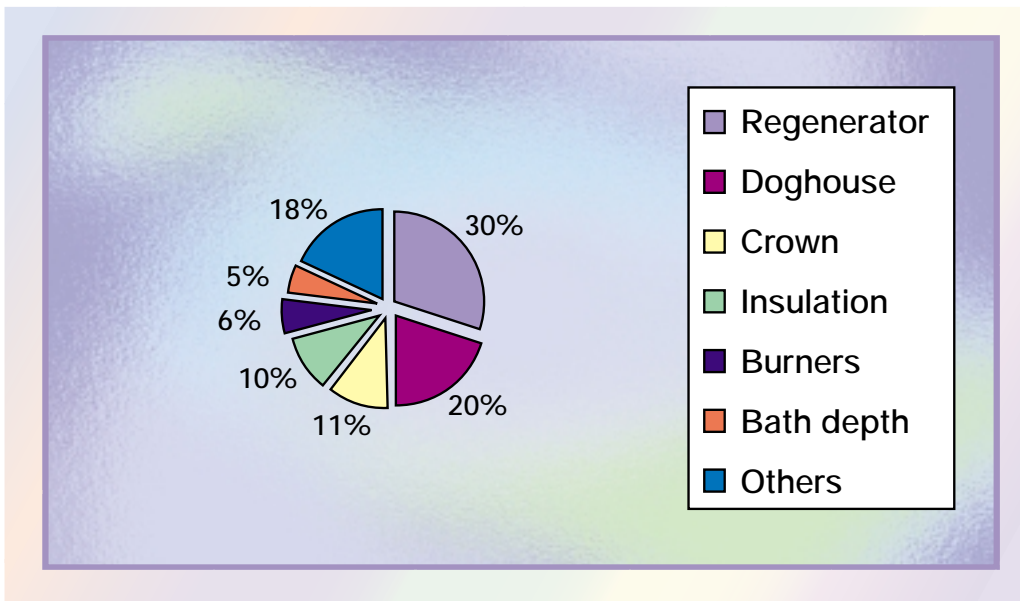


Fig 4 Relative contributions of various energy saving features

SAVINGS SUMMARY

Savings Achieved

The combined effects of the various improvements produced a 12.2% reduction in delivered energy consumption and an associated 33% decrease in energy costs. Total energy savings are calculated at 45,700 GJ valued at £312,800 pa (1997 prices). Of the saving made approximately 30% can be attributed to the upgraded regenerator packing, 20% to the sealed doghouse, 11% to the increased crown insulation and a further 10% to other furnace insulation. Savings from the low NOx burners and deeper glass bath are estimated at 6 and 5% respectively.

installing energy efficient features rather than standard features is estimated at £188,000.

Payback Period

A simple payback period of seven months was achieved. These savings include the elimination of oxygen and electric boost. Most other large glass operators do not have these functions, thus it is unlikely that a similar payback would be achieved on the marginal extra costs of specifying energy efficient features. A more typical industry payback would be 16 months based on the average energy price of £3.05 per GJ (see Section 4.1 Energy Consumption Guide 27 (revised 1997)¹.

POTENTIAL FOR REPLICATION IN THE UK GLASS INDUSTRY

Opportunities exist for the implementation of similar improvements within the glass industry where large continuous tank furnaces are operated.

A recent survey of the UK container industry reported that during 1996 this sector melted some 2,383,000 tonnes of glass at an average SEC of 4.97 GJ/t. If the 12% energy saving achieved at Lax & Shaw were replicated across this sector then energy savings of approximately 1.4×10^9 MJ (390 million kWh) per annum would accrue.

Many of the cost saving opportunities outlined in this case study can be replicated by other sites. Total savings are unlikely to be as large as at Lax & Shaw because not all use electrical boost, and oxygen usage is a rarity. Using £3.05 per GJ as the average cost of the fuel mix used by the industry, the estimated potential savings in the container sector would be £4 million per annum.

Total energy savings throughout the glass industry could potentially exceed this value, as many of the energy saving features incorporated in this container furnace could be replicated in other sectors, most notably in the domestic, flat and fibre sectors.

The Department of the Environment, Transport and the Regions' Energy Efficiency Best Practice Programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry, transport and buildings. The information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice Programme are shown opposite.

Further information

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Energy Efficiency in Buildings: helps new energy managers understand the use and costs of heating, lighting etc.